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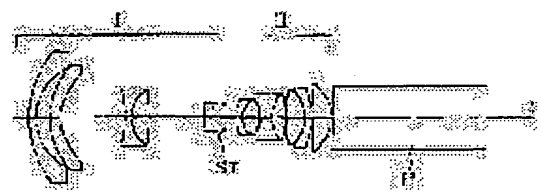
(54) PROJECTING LENS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a projecting lens keeping high resolving power though it has such a high viewing angle that a half viewing angle is ≥40° , necessary for the arrangement of a color synthesizing optical system and a color separating optical system, having long back focus and having high telecentricity.
SOLUTION: In this projecting lens, a first lens group I having negative refractive power and a second lens group II having positive refractive power are arranged from an enlarging side to a reducing side, and an aperture diaphragm ST is not provided between the first and the second lens groups, then the first lens group I has at least one aspherical lens. The focal distance (f) of the entire system of the lens, the focal distance f1 of the first lens group and the back focus Bf set when a conjugate point on the enlarging side is infinity satisfy conditions: (1) 4.5<Bf/f and (2) -2.0<f1/f<-1.0.



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2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The 1st lens group which has negative refractive power one by one toward a contraction side from an expansion side, and the 2nd lens group with forward refractive power are allotted, and it has an aperture diaphragm in the 1st and 2nd lens between groups, and grows into it. The above-mentioned 1st lens group It has at least one aspheric lens. Focal distance:f of the lens whole system, The focal distance of the lens [1st] group: Back focus:Bf in case the conjugate point by the side of f1 and expansion is infinite distance is condition: (1). $4.5<Bf/f$ (2) Lens for projection characterized by satisfying $-2.0<f1/f<-1.0$.

[Claim 2] Focal distance:f1p [as opposed to / in the lens for projection according to claim 1, the 1st lens group has one aspheric surface plastic lens, and / d line of this aspheric surface plastic lens] is condition: (3). Lens for projection characterized by satisfying $|f/f1p|<0.15$.

[Claim 3] The lens for projection with which an aperture diaphragm is characterized by having been arranged near the focal location by the side of expansion of the 2nd lens group in the lens for projection according to claim 1 or 2.

[Claim 4] forward and a negative one -- refractive-index:nf [as opposed to d line in any glass lens] -- condition: (4) Lens for projection characterized by satisfying $nf>1.65$. [in / in claims 1 or 2 or the lens for projection given in three, the 1st lens group has 1 or more sets of cemented lenses which have lamination and negative refractive power as a whole for a glass lens with negative refractive power, and a glass lens with forward refractive power, and / the above-mentioned cemented lens]

[Claim 5] When the lens which has the lens in which the 2nd lens group has the forward refractive power of at least two sheets in the lens for projection given in 1 of the arbitration of claims 1-4, and has refractive power forward [these] is counted from a contraction side, Abbe-number:nu of the 1st and the 2nd lens is condition: (5). Lens for projection characterized by satisfying $nu> 57$.

[Claim 6] The refractive index to d line of each lens with forward refractive power which the lens [2nd] group has in the lens for projection given in 1 of the arbitration of claims 1-5: nr is condition: (6). Lens for projection characterized by satisfying $nr<1.6$.

[Claim 7] The 2nd lens group is a lens for projection characterized by having at least one hybrid lens whose field which a thin resin layer is formed in the lens side of a glass lens in the lens for projection given in 1 of the arbitration of claims 1-6, and contacts the air of this resin layer is an aspheric surface configuration.

[Claim 8] Focal distance:f2p to d line of an aspheric lens with it is condition: (7). Lens for projection characterized by satisfying $|f/f2p|<0.1$. [the 2nd lens group has at least one aspheric lens made from plastics, and made / with an aspheric lens / from the above-mentioned plastics in the lens for projection given in 1 of the arbitration of claims 1-6,]

[Claim 9] It is the lens for projection characterized by for the 2nd lens group having the positive lens which has large curvature in a contraction side in order [side / contraction], a negative lens system, and the positive lens which has large curvature in a contraction side in the lens for projection given in 1 of the arbitration of claims 1-8, and joining mutually the positive lens by the side of the above-mentioned negative lens system and its expansion, or having air spacing.

[Claim 10] The lens for projection characterized by being the negative single lens with which a negative lens system has large curvature in an expansion side in the lens for projection according to claim 9.
[Claim 11] The lens for projection with which a negative lens system is characterized by consisting of a biconvex lens and a negative lens which is arranged at the expansion side of this biconvex lens, and has large curvature in an expansion side in the lens for projection according to claim 9.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the lens for projection which carries out expansion projection of the subject-copy image at a screen.
[0002]
[Description of the Prior Art] These days, the liquid crystal projector which carries out expansion projection of the image displayed on the liquid crystal panel etc. on display media, such as a screen, is spreading widely as objects for a display, such as a video recovery image and data of a computer.
[0003] Since the color picture as which "3 Plate type liquid crystal projector" which displays each color image of red, green, and blue on the independent liquid crystal panels (liquid crystal light valve etc.) of three sheets, compounds each color image, and carries out an enlarged display as a color picture especially is displayed on a display medium is highly minute, the diffusion rate is increasing.
[0004] In 3 plate type liquid crystal projector, generally, color separation optical system separates the light from the source of the white light into each color of red, green, and blue, and it leads to each liquid crystal panel. Compound the light (intensity modulation is carried out two-dimensional with the image displayed on each liquid crystal panel) injected from each liquid crystal panel according to color composition optical system, and incidence is carried out to the lens for projection. "The color composition optical system which consists of prism etc." will be arranged between the lens for projection, and a liquid crystal panel on the configuration.
[0005] For this reason, a long back focus required for arrangement of color composition optical system is needed for the lens for projection used for 3 plate type liquid crystal projector. Especially, in the projector using a "reflective-type liquid crystal panel" with large aperture efficiency, since color separation optical system is also inserted and arranged between the lens for projection, and a liquid crystal panel, "a longer back focus" is needed.
[0006] If the include angle of the flux of light which carries out incidence to color composition optical system changes from a liquid crystal panel, according to it, the spectral transmittance of color composition optical system will change, and the brightness of each color in the projected color picture will become the image which is hard to try to change with field angles.
[0007] for this reason, the tele cent from which the include angle of a chief ray is a contraction side, and the lens for projection becomes an optical axis and abbreviation parallel — it is desirable to have a

rucksack property.
[0008]
[Problem(s) to be Solved by the Invention] while this invention is the high field angle of 40 half-field angles or more — high resolving power — maintaining — sufficient long back focus for disposition of color composition optical system and color separation optical system — having — in addition — and let implementation of the lens for projection which has high tele cent rucksack nature be a technical problem.
[0009]
[Means for Solving the Problem] The lens for projection of this invention allots the 1st lens group I which has negative refractive power one by one toward a contraction side from an expansion side (left of drawing 1), and the 2nd lens group II with forward refractive power, has aperture-diaphragm ST in the 1st and 2nd lens between groups, and grows into it so that it may illustrate to drawing 1 . Since refractive power negative in the 1st lens group and the 2nd lens group have forward refractive power, this lens for projection is seen from an expansion side, and is a "retro focus mold."
[0010] The 1st lens group I has at least one aspheric lens.
The focal distance of the lens whole system: Back focus:Bf in case focal distance:f1 of f and the 1st lens group and the conjugate point by the side of expansion are infinite distance is condition: (1). $4.5<Bf/f$ (2) $-2.0<f1/f<-1.0$ are satisfied (claim 1).
[0011] For the lens for projection according to claim 2, focal distance:f1p [as opposed to / in the lens for projection according to claim 1, the 1st lens group has one plastics aspheric lens, and / d line of this plastics aspheric lens] is condition: (3). It is characterized by satisfying $|f/f1p|<0.15$.
[0012] The lens for projection according to claim 3 is characterized by having arranged the aperture diaphragm "near the focal location by the side of expansion of the 2nd lens group" in the lens for projection according to claim 1 or 2.
[0013] The lens for projection according to claim 4 is set on claims 1 or 2 or the lens for projection given in three. "A glass lens with negative refractive power, and a glass lens with forward refractive power The 1st lens group Lamination, forward and a negative one — refractive-index:nf [as opposed to d line in any glass lens] — condition: (4) It is characterized by satisfying $nf>1.65$. [in / it has the cemented lens which has negative refractive power as a whole" 1 or more sets, and / each cemented lens]
[0014] the time of the 2nd lens group counting the lens which has "a lens with the forward refractive power of at least two sheets", and has refractive power forward [these] from a contraction side in the lens for projection given in 1 of the arbitration of claims 1-4, as for the lens for projection according to claim 5 — Abbe-number:nu of the 1st and the 2nd lens — condition: (5) It is characterized by satisfying $nu> 57$.
[0015] Since the 2nd lens group has forward refractive power, naturally it has one or more "lenses with forward refractive power." The refractive index to d line of the "each lens with forward refractive power" with which the lens [2nd] group has a lens for projection according to claim 6 in the lens for projection of a publication in 1 of the arbitration of claims 1-5: nr is condition: (6). It is characterized by satisfying $nr<1.6$.
[0016] The lens for projection according to claim 7 is characterized by the 2nd lens group having at least one "the hybrid lens whose field which a thin resin layer is formed in the lens side of a glass lens, and contacts the air of this resin layer is an aspheric surface configuration" in the lens for projection given in 1 of the arbitration of claims 1-6.
[0017] focal distance:f2p [as opposed to / in the lens for projection given in 1 of the arbitration of claims 1-6, as for the lens for projection according to claim 8, the 2nd lens group has at least one "an aspheric lens made from plastics", and / d line of this "aspheric lens made from plastics"] — condition: (7) It is characterized by satisfying $|f/f2p|<0.1$.
[0018] In the lens for projection given in 1 of the arbitration of claims 1-8, the 2nd lens group has "the

positive lens which has large curvature in a contraction side in order [side / contraction], a negative lens system, and the positive lens which has large curvature in a contraction side", and the lens for projection according to claim 9 is characterized by what the positive lens by the side of the above-mentioned negative lens system and its expansion "has [it is joined mutually or] air spacing for."
[0019] In this case, a negative lens system can also be "a negative single lens which has large curvature in an expansion side", and can also consist of "a biconvex lens and a negative lens which is arranged at the expansion side of this biconvex lens, and has large curvature in an expansion side" (claim 11). (claim 10)
[0020] In order that the lens for projection of this invention may give a long back focus, it allots the 2nd lens group II which has forward refractive power in a 1st lens group [which has negative refractive power in an expansion side] I, and contraction side, and distribution of the refractive power of the 1st and 2nd lens group seen from the expansion side is considering it as the "retro focus lens" configuration which are "negative and forward."
[0021] Conditional expression (1) is for reconciling a big field angle with sufficient back focus for the need on the lens for projection of 3 plate type liquid crystal projector.
[0022] If it is going to enlarge a field angle, suppressing increase of the diameter of a lens, focal distance:f of the whole system is restricted naturally and cannot enlarge f freely.
[0023] If parameter:Bf/f exceeds the minimum of conditional expression (1), holding desired "big field angle", back focus:Bf will become short and arrangement of color composition optical system and color separation optical system, such as prism, will become difficult between the lens for projection, and a liquid crystal panel.
[0024] The back focus to focal-distance:f of the whole system when "principal-point spacing of the lens [1st] group and the lens [2nd] group" of a retro focus mold lens is generally set to d: Focal distance:f1 (<0) and the above-mentioned principal point spacing:d of the 1st lens group are used for the ratio of Bf (a). It is expressed $Bf/f=1-d/f1$. Therefore, the value of back focus:Bf will become large if the value of $|f1|$ becomes small.
[0025] Conditional expression (2) is for being compatible with a back focus long enough in good optical-character ability. Parameter: If f1/f exceeds the minimum of conditional expression (2), the negative refractive power of the 1st lens group becomes small, "retro focus nature" will become weak and it will become difficult to obtain a long back focus. Moreover, a parameter: If f1/f exceeds the upper limit of conditional expression (2), the negative refractive power of the 1st lens group will become excessive, and it will become difficult to keep good aberration outside a shaft, such as comatic aberration and a curvature of field.
[0026] If principal point spacing:d of the 1st lens group and the 2nd lens group is enlarged as shown in the above-mentioned formula (a), on the other hand, the lens by the side of expansion will become large, and it will become difficult to arrange "the lens of the forward refractive power which bears distortion aberration amendment of a retro focus mold lens" which can obtain a long back focus and which is generally performed.
[0027] The projector lens of this invention has amended distortion aberration appropriately by including an aspheric lens in the 1st lens group, without using the above-mentioned "lens of forward refractive power."
[0028] The aspheric lens in the 1st lens group is cheap, and it is desirable to consider as a plastics aspheric lens made from the easy plastics of shaping.
[0029] However, the change of the focal distance according to a temperature change as compared with optical glass of a plastic lens is large.
[0030] In the liquid crystal projector of a rear mold, since the lens for projection is completely stored in a case after it is installed, readjustment of a focus and a scale factor is difficult, and it is necessary to consider degradation of the image by focal distance change enough.
[0031] Conditional expression (3) regulates "the degree of the focal distance change by temperature" of

an aspheric surface plastic lens. Parameter: If |f/f1p| exceeds the upper limit of conditional expression (3), when focal distance:f1p changes in connection with a temperature change, "the scale factor of an image" changes a lot, and a big focus gap generates and is not desirable.
[0032] While securing high tele cent rucksack nature for the arrangement location of the aperture diaphragm arranged the 1st and 2nd lens between groups like by [according to claim 3] setting up near the expansion side focal location of the 2nd lens group, high aperture efficiency is realizable.
[0033] Like the lens for projection according to claim 4, good amendment of axial overtone aberration is attained by constituting cemented lenses including a "cemented lens" from "lamination of two glass lenses from which distribution differs" in the 1st lens group.
[0034] The cemented lens in the 1st lens group makes refractive power negative in order to obtain a long back focus. thus, forward and the negative ones which constitutes a cemented lens since it will become difficult for the PETTSU bar sum to increase to negative and to maintain the surface smoothness of the image surface, if it carries out — any lens makes it possible to prevent the PETTSU bar sum increasing to negative, and to maintain the surface smoothness of the image surface by making "refractive-index:nf to d line" larger than 1.65.
[0035] Since the chief ray besides the shaft which carries out incidence to the lens for projection from a liquid crystal panel has high tele cent rucksack nature, it is greatly bent in the direction of an optical axis with a lens with the forward refractive power arranged at the contraction side in the 2nd lens group, but at this time, if "the difference of the straight degree by the difference in wavelength" of a beam of light is large, the chromatic aberration of magnification will break out.
[0036] So, with the lens for projection according to claim 5, the Abbe number of the "at least two positive lenses" arranged at the contraction side in the 2nd lens group is chosen appropriately (conditional expression (5)), and the outbreak of the chromatic aberration of magnification is suppressed.
[0037] Conditional expression (6) is for securing the surface smoothness of the image surface.
[0038] Parameter: If nr exceeds an upper limit, since the refractive index of a lens with the forward refractive power in the 2nd lens county will become large and the curvature of a lens side will become small in connection with it, the PETTSU bar sum of the lens for projection will increase to negative, and it becomes difficult to maintain the surface smoothness of the image surface.
[0039] It is possible by adopting the aspheric surface in the 2nd lens group with the lens for projection of this invention at at least one sheet to amend spherical aberration, comatic aberration, and astigmatism by small lens number of sheets.
[0040] With the lens for projection according to claim 7, it considered as the "aspheric lens of a hybrid mold" which made the aspheric surface the field which forms a thin resin layer in the lens side of a glass lens, and contacts the air of this resin layer in the aspheric lens in the 2nd lens group, and few lenses for projection of property fluctuation are realized to a temperature change.
[0041] With the lens for projection according to claim 8, it made it possible to have the image engine performance stabilized to the temperature change by arranging an aspheric lens made from plastics and satisfying conditional expression (7) further in the 2nd lens group.
[0042] Parameter: If |f/f2p| exceeds the upper limit of conditional expression (7), when focal distance:f2p changes in connection with a temperature change, "the scale factor of an image" changes a lot, and a big focus gap generates and is not desirable.
[0043] With claim 9 thru/or the lens for projection given in 11, when the 2nd lens group has "the positive lens which has large curvature in a contraction side in order [side / contraction], the negative lens system which has large curvature in an expansion side, and the positive lens which has large curvature in a contraction side", the chromatic aberration of magnification, comatic aberration, and astigmatism are amended good.
[0044]
[Embodiment of the Invention] Hereafter, six examples are given as a gestalt of concrete operation. In each example, the field number counted from the expansion side by "S" is expressed, "R" expresses

the radius of curvature (if it is in the aspheric surface, it is paraxial radius of curvature) of each side (the field of aperture-diaphragm ST and the field of the prism P of color composition and a segregate are included), and "D" expresses the spacing on an optical axis.

[0045] "Nd" and."nud" show the refractive index and Abbe number to d line of the quality of the material of each lens. In the F value and "omega" to which "f" expresses the focal distance of the lens for projection, and "F/No" expresses brightness, a half-field angle and "obd" express the distance from a body to the first page of a lens, and "bf" expresses the back focus in the inside of air (condition without prism). In addition, the unit of an amount with the dimension of die length is "mm."

[0046] Height:h [as opposed to / the configuration of the aspheric surface makes an intersection with an optical axis a zero, and / an optical axis], change:Z of the direction of an optical axis, paraxial radius-of-curvature:R, cone constant:K, the aspheric surface multiplier of a high order term : as A, B, C, D, and E A well-known formula: Express with Z= (1/R) and h2/[1+root[1- (1+K) (1/R), 2, and h2]+A-h4+B-h6+C-h8+D-h10+E-h12, and give and specify Above R, K, A, B, C, D, and E.

[0047]

[Example] The lens configuration of the projector lens of an example 1 is shown in example 1 drawing 2 . It is the configuration of having allotted the 1st lens group I which has negative refractive power from an expansion side (drawing left-hand side), aperture-diaphragm ST, and the 2nd lens group II with forward refractive power.

[0048] f= 10.5, F/No=2.9, omega= 40.2 degrees, obd=873.47, bf=50.02S R D Nd nud1 52.688 3.600 1.65844 50.92 27.229 7.4283 44.957 5.000 1.49154 57.84 19.755 40.8005 - 23.504 3.353 1.77250 49.66 - 21.443 5.6417 - 17.164 4.400 1.65844 50.98 15.9106.0001.69895 30.19 -44.104 8.00010 infinity (diaphragm) 0.30011 76.916 3.000 1.74330 49.212 12.067 5.238 1.59270 35.513 - 95.5899.80014 -487.450 6.0001.83400 37.315 21.783 9.150 1.48749 70.416 - 20.959 0.30017 -841.689 8.052 1.58313 59.518 - 19.403 0.30019 - 21.441 3.000 1.80450 39.620 370.8140.1401.52020 52.021 -78672.130 0.44822 54.736 10.049 1.51680 64.223-27.772 1.00024 infinity 80.000 1.83400 37.325 infinity The 5.527 24th side and, and the 25th page are fields by the side of expansion of Prism P, and contraction.

[0049] aspheric surface 4th page: — K=-0.491036 and A= -0.123319x10-4 and B= -0.147551x10-8 and C= -0.421984x10-10 and D= 0.322017x10-13 — the E=-0.148201x10-16 21st page : (Front face of the resin layer of a hybrid lens) K= -0.61239x1013, A= 0.668855x10-5, B= 0.497968x10-8, and C= — value (1) of -0.203070x10-10, D= 0.136449x10-12, and E=-0.267955x10 -15 conditional expression Bf/f=4.76 (2) f1/f=-1.94 (3) |f/f1p|=0.14 (4) nf=1.65844 (5) nu= 59.5 (6) nr=1.58313 conditional expression (4), Conditional expression (6) shows the largest value for the value in the target numeric value with the smallest value of (5). Also in each following example, it is the same. The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 1 to drawing 8 and 9 is shown. Criteria wavelength is made into "546nm e line." S in an astigmatism Fig. shows the sagittal image surface, and M shows the case of a meridional image surface. Also in other aberration Figs., it is the same.

[0050] It imitates and the lens configuration of the projector lens of an example 2 is shown in example 2 drawing 3 at drawing 2 .

[0051] f= 10.2, F/No=2.9, omega= 40.7 degrees, obd=853.53, bf=59.94S R D Nd nud1 57.470 3.600 1.65844 50.92 29.323 8.2363 50.000 5.000 1.49154 57.84 21.857 27.0235 - 34.624 3.000 1.77250 49.66 - 45.571 33.6827 - 17.951 3.000 1.65844 50.98 14.0906.1361.69895 30.19 -32.362 4.56810 infinity (diaphragm) 5.83111 42.882 3.000 1.74330 49.212 11.792 8.011 1.59270 35.513 - 26.1240.92214 -20.711 6.0001.83400 37.315 28.563 8.909 1.49700 81.616 - 20.4500.30017 11800.357 8.465 1.48749 70.418 - 19.634 0.30019 - 22.844 3.000 1.80450 39.620 -272.6350.140 1.52020 52.021 -122.828 0.30422 94.236 10.573 1.49700 81.623 -24.5881.00024 infinity 80.000 1.83400 37.325 infinity The 15.474 24th side and, and the 25th page are fields by the side of expansion of Prism P, and contraction.

[0052] aspheric surface 4th page: — K=-0.593166 and A= -0.105994x10-4, B= 0.247284x10-8, and C= - 0.383224x10-10 and D= 0.361966x10-13 — the E=-0.148980x10-16 21st page : (Front face of the resin

layer of a hybrid lens) K=-40.608663, A= 0.668864x10-5, B= 0.128436x10-7, and C= — value (1) of - 0.202201x10-10, D= 0.693164x10-13, and E=-0.165116x10 -15 conditional expression Bf/f=5.86 (2) f1/f=-1.95 (3) |f/f1p|=0.12 (4) nf=1.65844 (5) nu= 70.4 (6) The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 2 to nr=1.49700 drawing 10 and 11 is shown.

[0053] It imitates and the lens configuration of the projector lens of an example 3 is shown in example 3 drawing 4 at drawing 2 .

[0054] f= 10.2, F/No=2.9, omega= 41.1 degrees, obd=841.52, bf=66.95S R D Nd nud1 67.413 3.600 1.65844 50.92 29.538 9.1903 54.269 5.000 1.49154 57.84 22.691 63.4105 - 52.071 3.140 1.77250 49.66 - 37.020 0.9557 - 20.387 3.000 1.74330 49.28 14.6494.6241.80518 25.59 -97.339 0.58810 infinity (diaphragm) 11.72811 49.859 3.000 1.74330 49.212 13.732 7.979 1.59270 35.513 - 19.1410.59414 -18.308 6.0001.83400 37.315 26.888 8.628 1.48749 70.416 - 24.680 0.36717 285.287 8.264 1.49700 81.618 - 22.339 0.30019 - 26.683 3.0001.80450 39.620 -182.090 0.1401.52020 52.021 -119.714 0.44922 97.824 11.045 1.49700 81.623-25.054 1.00024 infinity 80.0001.8340037.325 infinity The 22.467 24th side and, and the 25th page are fields by the side of expansion of Prism P, and contraction.

[0055] aspheric surface 4th page: — K=-0.584709 and A= -0.103901x10-4, B= 0.574548x10-8, and C= - 0.334481x10-10 and D= 0.380006x10-13 — the E=-0.220860x10-16 21st page : (Front face of the resin layer of a hybrid lens) K=-24.133520, A= 0.638716x10-5, B= 0.126009x10-7, and C= — value (1) of - 0.256845x10-10, D= 0.678583x10-13, and E=-0.961669x10 -16 conditional expression Bf/f=6.60 (2) f1/f=-1.38 (3) |f/f1p|=0.12 (4) nf=1.74330 (5) nu= 81.6 (6) The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 3 to nr=1.49700 drawing 12 and 13 is shown.

[0056] It imitates and the lens configuration of the projector lens of an example 4 is shown in example 4 drawing 5 at drawing 2 .

[0057] f= 10.2, F/No=2.9, omega= 41.1 degrees, obd=837.28, bf=68.70S R D Nd nud1 62.664 3.600 1.65844 50.92 32.506 7.4573 47.174 5.000 1.49154 57.84 24.443 34.3855 - 53.992 3.000 1.77250 49.66 19.392 9.775 1.69895 30.17 -94.188 29.2588 -32.067 3.0001.74330 49.2942.868 3.667 1.80518 25.510 - 469.457 3.10211 infinity (diaphragm) 6.10812 31.658 3.000 1.7433049.21313.649 8.3251.59270 35.514- 19.578 0.55615-19.075 6.0001.83400 37.316 25.376 6.704 1.48749 70.417 - 54.996 0.36218 114.809 9.596 1.49700 81.619 - 20.337 0.30020 - 22.434 3.1871.80450 39.621 - 43.995 0.140 1.52020 52.022 - 37.313 0.31923-1118.073 10.1571.49700 81.624 -25.491 1.00025 infinity 80.000 1.83400 37.326 infinity The 24.216 25th side and, and the 26th page are fields by the side of expansion of Prism P, and contraction.

[0058] aspheric surface 4th page: — K=-0.461683 and A= -0.816116x10-5, B= 0.513609x10-8, and C= - 0.341545x10-10 and D= 0.386224x10-13 — the E=-0.194862x10-16 22nd page The value of :K=- 1.797504, A= 0.418090x10-5, B= 0.115048x10-7, C=-0.167059x10-10, D= 0.925131x10-13, and E=- 0.154977x10 -15 conditional expression (Front face of the resin layer of a hybrid lens) (1) Bf/f=6.77 (2) f1/f=-1.03 (3) |f/f1p|=0.09 (4) nf=1.69895 (5) nu= 81.6 (6) To nr=1.49700 drawing 14 and 15 The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 4 is shown.

[0059] It imitates and the lens configuration of the projector lens of an example 5 is shown in example 5 drawing 6 at drawing 2 .

[0060] The 2nd negative lens (hybrid lens) and the 3rd positive lens are joined from the contraction side in the 2nd lens group.

[0061] f= 10.2, F/No=2.9, omega= 41.1 degrees, obd=837.04, bf=69.43S R D Nd nud1 78.698 3.600 1.65844 50.92 32.302 4.5573 38.447 5.000 1.49154 57.84 26.748 29.4545 - 63.345 3.000 1.77250 49.66 20.004 11.335 1.69895 30.17 -142.527 36.0008 -25.245 3.0001.74330 49.2955.966 3.666 1.80518 25.510 - 103.928 2.94011 infinity (diaphragm) 6.02312 36.425 3.000 1.7433049.21313.852 8.2791.59270 35.514- 21.943 0.30015-23.945 6.000 1.83400 37.316 24.035 6.618 1.48749 70.417-73.104 0.30018 93.571 9.628 1.49700 81.619 - 19.951 3.118 1.80450 39.620 - 37.118 0.140 1.52020 52.021 - 31.979 0.30022 -198.147 10.734 1.49700 — 81.623-23.636 1.00024 infinity 80.000 1.8340037.325 infinity24.954 — the 24th page and the 25th page are fields by the side of expansion of Prism P, and contraction.

[0062] aspheric surface 4th page: — K=−0.391352 and A= −0.851556x10−5, B= 0.454772x10−8, and C= −0.288305x10−10 and D= 0.323527x10−13 — the E=−0.153315x10−16 21st page The value of :K=−1.437959, A= 0.397248x10−5, B= 0.137357x10−7, C=−0.105581x10−10, D= 0.127601x10−12, and E=−0.204259x10 −15,conditional expression (Front face of the resin layer of a hybrid lens) (1) Bf/f=6.84 (2) f1/f=−1.07 (3) |f/f1p|=0.05 (4) nf=1.69895 (5) nu= 81.6 (6) To nr=1.49700 drawing 16 and 17 The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 5 is shown.

[0063] It imitates and the lens configuration of the projector lens of an example 6 is shown in example 6 drawing 7 at drawing 2 .

[0064] In the 2nd lens group, one aspheric lens (a contraction side to the 2nd biconvex lens) made from plastics is arranged.

[0065] f= 10.5, F/No=2.9, omega= 40.3 degrees, obd=870.00, bf=53.49S R D Nd nud1 57.465 3.600 1.65844 50.92 28.337 5.1393 38.755 5.000 1.49154 57.84 21.705 19.6805 − 33.220 3.000 1.77250 49.66 − 59.074 34.2187 − 16.777 3.000 1.65844 50.98 14.2095.1661.69895 30.19 −39.964 1.44910 infinity (diaphragm) 0.30011 51.250 3.000 1.74330 49.212 12.920 5.375 1.59270 35.513 − 85.64511.36214 − 318.252 6.0001.83400 37.315 22.158 8.885 1.48749 70.416 − 27.1900.30017 92.053 8.885 1.49700 81.618 − 21.445 0.30019 − 26.133 3.000 1.80450 39.620 −235.2870.30021 230.483 4.100 1.49154 57.822 −129.260 0.30023−397.916 7.6391.4970081.624 −27.932 1.00025infinity 80.0001.83400 37.326 infinity The 9.000 25th side and, and the 26th page are fields by the side of expansion of Prism P, and contraction.

[0066] aspheric surface 4th page: — K=−0.605096 and A= −0.119305x10−4 and B= −0.101656x10−7 and C= −0.248655x10−10 and D= −0.299890x10−15 — the E=0.280185x10−16 22nd page : (Contraction side face of a contraction side to the 2nd biconvex lens) K=−53.290851, A= 0.190738x10−5, B= 0.903260x10−8, and C= — value (1) of −0.225838x10−10, D= 0.338009x10−14, and E=0.382932x10 −16 conditional expression Bf/f=5.12(2) f1/f=−1.29 (3) |f/f1p|=0.09 (4) nf=1.65844 (5) nu= 57.8 (6) nr=1.49700 (7) To |f/f2p|=0.06 drawing 18 and 19 The aberration Fig. which is a contraction side and evaluated the lens for projection of an example 6 is shown.

[0067] The lens for projection of the examples 1−6 given above all allots the 2nd lens group II which has the 1st lens group I and the forward refractive power which have negative refractive power one by one toward a contraction side from an expansion side, and has aperture−diaphragm ST in the 1st and 2nd lens between groups.

[0068] A back focus in case at least one aspheric lens (the 2nd is an aspheric lens from an expansion side for each example) is arranged at the lens [1st] group I and focal−distance:f1 of focal−distance:f of the projector−lens whole system and the lens [1st] group and the conjugate point by the side of expansion are infinite distance: Bf is condition: (1). 4.5<Bf/f (2) −2.0<f1/f <−1.0 are satisfied (claim 1).

[0069] Moreover, focal distance:f1p and focal distance:f of the above−mentioned whole system to d line of the aspheric surface plastic lens (each example an expansion side to 2nd lens) arranged in the 1st lens group I are condition: (3). |f/f1p|<0.15 are satisfied (claim 2) and aperture−diaphragm ST is arranged near the focal location by the side of expansion of the 2nd lens group II (screen side) (claim 3).

[0070] as for examples 1−6, lamination "the cemented lens which has negative refractive power as a whole" all arranges the glass lens which has negative refractive power in the 1st lens group, and one or more glass lenses with forward refractive power — having (example 1− one sheet in 3 and 6) examples 4 and 5 — two sheets, and forward and a negative one — refractive−index:nf [as opposed to d line in any glass lens] — condition: (4) nf>1.65 are satisfied (claim 4).

[0071] Moreover, the lens with which each lens for projection of examples 1−6 has the forward refractive power of at least two sheets in the 2nd lens group is arranged. It counts from a contraction side and Abbe−number:nu of the 1st and the 2nd positive lens is condition: (5). A refractive index [as opposed to / satisfy nu> 57 (claim 5) and / d line]: nr is condition: (6). nr<1.6 are satisfied (claim 6).

[0072] A resin layer with the lens for projection of examples 1−5 thin in the 2nd lens group is formed in the lens side of a glass lens. It has the hybrid lens (each example a contraction side to 2nd lens) whose

field in contact with air is an aspheric surface configuration (claim 7). The lens for projection of an example 6 Focal distance:f2p [as opposed to / an aspheric lens (from an expansion side to the 2nd) made from the plastics of one sheet into the 2nd lens group is arranged, and / the d line] is condition: (7). $|f/f2p|<0.1$ are satisfied (claim 8).

[0073] As shown in drawing 2 -7, as for the 2nd lens group II of the lens for projection of examples 1-6, the positive lens which has large curvature in a contraction side in order [side / contraction], the negative lens system, and the positive lens with which it has large curvature in a contraction side are arranged (claim 9). In an example 1 thru/or 5, a negative lens system is a negative single lens which has big curvature in "expansion side, and this negative lens system has an air gap between the positive lenses by the side of expansion in an example 1 thru/or 4, and is made to rival the positive lens by the side of expansion in the example 5 (claim 10). Moreover, the above-mentioned negative lens system is constituted from the example 6 by "the biconvex lens and the negative lens which is arranged at the expansion side of this biconvex lens, and has large curvature in an expansion side" (claim 11).

[0074]

[Effect of the Invention] According to this invention, as explained above, as shown in each example, high resolving power is maintained with the high field angle of 40 half-field angles or more, and the projector lens which has a long back focus and high tele cent rucksack nature can be realized.

[0075] Especially the lens for projection of this invention is easy to carry in the reflective type liquid crystal projector which arranges color composition optical system and color separation optical system between a liquid crystal panel and the lens for projection, and becomes it is bright and possible [the thing with big "aperture efficiency which is the description of a reflective type liquid crystal projector for which high quality image" is realized].

[0076]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing explaining the projector lens of this invention.
[Drawing 2] It is drawing showing the lens configuration of an example 1.
[Drawing 3] It is drawing showing the lens configuration of an example 2.
[Drawing 4] It is drawing showing the lens configuration of an example 3.
[Drawing 5] It is drawing showing the lens configuration of an example 4.
[Drawing 6] It is drawing showing the lens configuration of an example 5.
[Drawing 7] It is drawing showing the lens configuration of an example 6.
[Drawing 8] It is an aberration Fig. about an example 1.
[Drawing 9] It is an aberration Fig. about an example 1.
[Drawing 10] It is an aberration Fig. about an example 2.
[Drawing 11] It is an aberration Fig. about an example 2.
[Drawing 12] It is an aberration Fig. about an example 3.

[Drawing 13] It is an aberration Fig. about an example 3.
[Drawing 14] It is an aberration Fig. about an example 4.
[Drawing 15] It is an aberration Fig. about an example 4.
[Drawing 16] It is an aberration Fig. about an example 5.
[Drawing 17] It is an aberration Fig. about an example 5.
[Drawing 18] It is an aberration Fig. about an example 6.
[Drawing 19] It is an aberration Fig. about an example 6.
[Description of Notations]
I The 1st lens group
II The 2nd lens group
ST Diaphragm
P Prism of color composition and a color separation system

[Translation done.]